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MENTAL AND PHYSICAL CORRESPONDENCE IN TWINS

By ARNOLD GESELL, Ph.D., M. D.

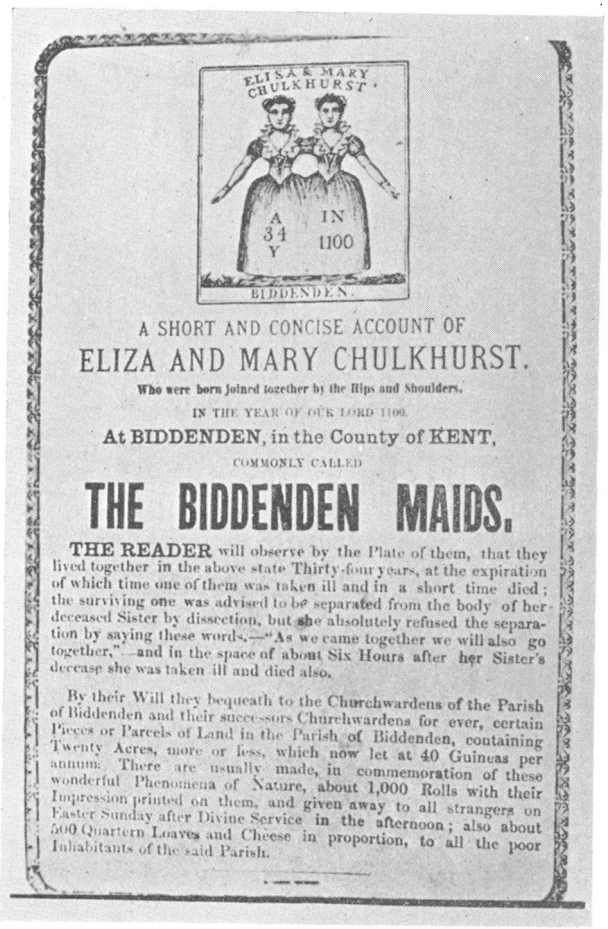
DIRECTOR OF YALE PSYCHO-CLINIC, NEW HAVEN, CONN.

I. The Study of Twins

TWINS have always captured the curiosity and imagination of man. They figure in myths, traditions, superstitions, in art, in humor and in advertising. They are written in the constellations. Recently they have become one of the problems of science. Ancient Assyrians, Babylonians, Egyptians, Indians, as well as Hottentots used to kill both or one of a pair of twins, on the theory that twins were omens of ill luck or a form of sin. Though we hold no such erroneous conception, now-a-days, there is still a great deal of romancing about twins.

An antiquarian could compile a very interesting history of the subject. He could show how monsters and double monsters have left their impress upon legend and superstition. He could review for us the prescientific interpretations of such monsters and twins. Gould and Pyle in their *Anomalies & Curiosities of Medicine* have collected interesting facts revealing the extravagant and absurd character of these interpretations. Classical writings are sprinkled with truthful observations and conjectures; but modern embryology and teratology which have shed scientific light on the problems of twinning may be said to date back only to the eighteenth century.

The popular interest in twins, which is itself a suggestive psychological phenomenon, is by no means of recent date. For example, we have evidence to show that the Biddenden Maids who were born in Kent in 1100 A. D. excited quite the same curiosity which did the Siamese twins in the days of P. T. Barnum. The broadside reproduced from Ballantyne's *Antenatal Pathology* sums up the facts regarding this historical case (Figure 1). Whether these sisters were actually united by the arms may be questioned;



Reproduced from Ballantymes Antenatal Pathology and Hygiene. Wm. Green & Sons, Edbg., 1904, p. 642.

FIGURE 1. "BROADSIDE" OF THE BIDDENDEN MAIDS

but there is no doubt that by their twin will they bequeathed twenty acres, the income from which the church wardens were instructed to spend in distributing cakes (bearing the impression of their conjoined image) to all strangers in Biddenden, at the close of divine service each Easter; and also "270 quartern loaves, with cheese in proportion, to all the poor in said parish."

About four centuries later, at about the time when America was discovered, we have another historical instance, the dicephalic twins, known as "the Scottish Brothers." They were described in quaint language by the Scottish historian, Lindesay, as follows:

In this mean Time there was a great Marvel seen in Scotland. A Bairn was born reckoned to be a Man-Child; but, from the Waste up, was two fair Persons, with all Members and Portraitures pertaining to two Bodies, to wit,

Two Heads, well-eyed, well-eared, and well-handed. The two Bodies, the One's Back was fast to the Other's; but, from the Waste down, they were but one Personage, and could not know by the Ingyne of Man, from which of the two Bodies the Legs and Privy Members proceeded. Notwithstanding the King's Majesty caused take great Care and Diligence upon the Upbringing of their two Bodies in one Personage, caused nourish them, and learn them to sing and play upon Instruments of Musick; who, within short Time, became very ingenious and cunning in the Art of Musick; whereby they could sing and play two Parts; the one the Treble, and the other the Tenor; which was very dulce and melodious to hear. The common People who treated them also, wondered that they could speak diverse and sundry Languages; that is to say, Latin, French, Italian, Spanish, Dutch, Danish, English, and Irish. Their two Bodies long continued, to the age of twenty-eight years; and the one departed long before the other, which was dolorous and heavy to the other; for which many required of the other to be merry. He answered, How can I be merry, that have my true Marrow as a dead Carrion about my Back, which was wont to sing and play with me. When I was sad he would give me Comfort, and I would do the like to him; But now I have nothing but Dolour of the Bearing so heavy a Burden, dead, cold, and unsavory, on my Back, which taketh all earthly Pleasure from me in this present Life: Therefore I pray to Almighty God, to deliver me out of this present Life, that we may be laid and dissolved in the Earth, wherefrom we came.

The Hungarian sisters were born in 1701, and died almost simultaneously in their twenty-second year. They were conjoined twins, similar to the Biddenden sisters, and according to Gould and Pyle excited great curiosity. This curiosity was not limited to the populace. The twins were exhibited all over Europe, were examined by scientists, celebrated by poets (including Pope), described by Buffon in his Natural History, and memorialized in a Latin poem and in a bronze statuette. The sisters Millie-Christine (colored, born 1851); the Bohemian sisters (born 1878); the sisters Ritta-Christina (born in Sardinia, 1829); the Tocci brothers (born in Turin, 1877), all were conjoined twins and more or less famous in their day.

Most famous of all, however, were the Siamese twins (Figure 2), who were discovered in Siam and rescued by a British merchant, in 1824, when they were about thirteen years old. They were rescued in this sense. King Chowpahyi was planning to put them to death, because he thought they might bring evil to his country; but the merchant prevailed upon his majesty to allow them to go away for exhibition. They went directly from Siam to Boston, and later were shown the world over. Although of Chinese extraction, they adopted America as their home, settled down as farmers in North Carolina, under the name of Bunker, and married two sisters at the age of forty-four. They became Christians; and died in 1874.

From the time when they landed in Boston and were examined

From Gould & Pyle Anomalies and Curiosities of Medicine.
W. B. Saunders, Phdpha., 1897, p. 168.

FIGURE 2. THE SIAMESE TWINS AT THE AGE OF 18

by a Harvard professor, they became the object of both scientific and popular attention. A vast amount of literature has been written in regard to them. In 1830 a scientific memoir was read before the Royal Society of London, and is to be found in the Philosophical Transactions of that year. The memoir reports a lack of strong resemblance in Chang and Eng; striking correspondences in their pulse rates and in their tastes; reciprocity of symptoms under similar conditions of disorder; differences in dreams; and a remarkable degree of consent and mutual adjustment displayed in the physical movements of the twins. It is comforting to know that Chang and Eng could playfully tumble head over heels, without the slightest inconvenience. The author of this fascinating report, rather naïvely remarks that "they are at present very much attached to each other." As a matter of fact until their death they showed an affectionate forebearance for one another; and a highly developed sympathy, understanding and adaptation.

To bring this historical retrospect to date, it should be mentioned that there are at the present writing living in Washington a pair of "Siamese twins," natives of the Philippines, boys now in their teens. Under a ruling of the director of the census bureau they were counted as two persons in the last enumeration.

Twins have played a prominent part in modern medical literature, and the annual volumes of the "Index Medicus" and the Surgeon General's catalogue carry a considerable number of titles of articles on some phase of the subject. Significantly enough there is usually one group of references sub-classified under the head of *Twins, one blighted.* Taruffii in his monumental work on Teratology devotes 1,650 pages to the consideration of double monsters.

For biologists, twinning has become a problem of central importance. Bateson has defined twinning as the production of equivalent structures by division; and emphasized its fundamental nature. Important studies in symmetry, asymmetry, teratology, sex and heredity, have been made in this field. H. H. Newman, of the University of Chicago, has made extensive studies of twin production, habitually exhibited in the nine-banded armadillo of Texas; and has written a valuable volume on The Biology of Twins.[1] H. H. Wilder has reported in *The American Journal of Anatomy,* studies of physical resemblances in twins, shown by skin patterns of soles and palms. Galton has made a similar comparison of finger prints in 17 pairs of twins. Baldwin has made physical measurements of 3 pairs of fraternal twins and determined their differences in anatomical ages.

In 1918, The American Genetic Association announced its desire to communicate with twins living in any part of the world. Six hundred twins and parents of twins responded with letters and photographs; and in December, 1919, the Journal of Heredity devoted an entire number to discussion of the data on the general subject. This number contains an article by Dr. C. H. Danforth on Resemblance and Difference in Twins. Goddard devotes two pages to certain eugenic phases of the problem in his work on "Feeblemindedness: its Causes and Consequences."

The present writer, in 1921, published a study of 40 cases of hemi-hypertrophy, and discussed this condition in relation to mental defect and to twinning.[2] Hemi-hypertrophy is a unilateral enlargement of the body, which is interpreted as a developmental

[1] Newman H. H., *The Biology of Twins* (*Mammals*), University of Chicago Press, 1917; pp. 186.

[2] Gesell, Arnold, Hemi-hypertrophy and mental defect. *Archives of Neurology and Psychiatry,* Vol. VI, pp. 400-423.

anomaly dating back to an early embryonic stage of cleavage,—a form of asymmetry due to a possible deviation in the normal process of twinning. The relatively frequent complication of mental defect is attributed to an abnormality in this process of bilateral twinning which involves a disturbance of normal tissue development.

The psychological aspects of the phenomenon of twins have not received their full share of attention. There are, however, two notable exceptions. The versatile Galton, who left few human problems untouched, made a suggestive, though rather leisurely, excursion into the subject in his *Inquiries into Human Faculty* in the year 1883. He used the questionnaire method and reported the returns of 80 cases of close similarity. Much of his material was anecdotal; but it was used to good advantage to prove the dominating influence of nature over nurture. He found only two cases of strong bodily resemblance being accompanied by mental diversity. He makes this characteristic suggestion: "It would be an interesting experiment for twins who were closely alike to try how far dogs could distinguish between them by scent!"

In 1904, Thorndike published an important monograph entitled "Measurements of Twins," based on precise measurements of 50 pairs of unselected public school twins from 9 to 15 years old, in 6 mental traits, and 8 physical traits. "The arguments concerned the lack of differences in the amount of resemblance (1) between young and old twins, (2) between traits little, and traits much subject to training and (3) between mental and physical traits, and also the great increase in resemblance of twins over ordinary siblings. The resemblance of twins was found to be approximately .80 or .75 to .80 in amount." The author considers that his data give well-nigh conclusive evidence that the mental likenesses found in the case of twins and the differences found in the case of non-fraternal pairs, when the individuals compared belonged to the same age, locality and educational systems, are due, to at least nine-tenths of their amount to original nature.[3]

"The form of distribution of twin resemblance seems to be that of a fact with a central tendency at about .80 and with a great variability, restricted towards the upper end by the physiological limit of complete identity. Such a distribution would be most easily explained by the genesis of twins as a rule from two ova and by a great reduction of the variability of contemporaneous germs and ova below that of germs and ova developed at different times." (p. 63.)

[3] Thorndike, Edward L. Measurements of Twins, *Archives of Philosophy, Psychology and Scientific Methods,* Vol. I, pp. 1-64.

Thorndike therefore refuses to classify twins into the two classical divisions, duplicate and fraternal. He does not find two coherent species of resemblance; and he doubts that there are but two corresponding modes of genesis (monozygotic and dizygotic). He believes that there is considerable specialization of resemblance in all type of twins. Although he finds that resemblance in general appearance and countenance is correlated by no means perfectly with resemblance in other traits, his figures show a tendency toward such resemblance. The medians of resemblance in (1) three head measurements, (2) in three stature and arm measurements, (3) in perception, (4) in association,—of twins of the same sex (a) closely alike and (b) not much alike in countenance are as follows: 1. (a) 85, (b) 70. 2. (a) 86, (b) 59. 3. (a) 84, (b) 63. 4. (a) 94, (b) 70.

II. A Clinical Comparison of Duplicate Twins

We report herewith a case, or rather a pair of cases, which will serve as a basis for the consideration of the problem of resemblances in twins. We became interested in these two children, not because they were twins, but because of the exceptional superiority of their intelligence; and they were first studied from this point of view. Accumulating evidence, however, gradually convinced us that, regardless of their caliber, they presented a remarkable degree of correspondence in physical and mental constitution. It is this correspondence which is here emphasized. The facts have psychological interest, and may not be without some biological significance.

The twins will be referred to with an impersonal A and B, because there is no intention to publicly extoll them. We are not concerned to reveal their identity—except in the sense indicated by the term "identical twins!"

(a) Developmental History

A complete family chart of the twin sisters A and B would show evidence of superior endowment in the immediate ancestry on both the maternal and paternal sides. Scientific and linguistic ability of high order and physical energy are some of the traits which are found in the two immediate generations. The trait of twinning likewise has a hereditary basis in this instance; for the mother also bore two boys, twins who died in infancy.

Their sisters A and B were born six years later, by Caesarian section, somewhat prematurely, weighing respectively 4.3 and 5.3 pounds. They thus escaped some of the hazard and strains which may accompany birth.

Their prematurity did not hinder precocity. At any rate,

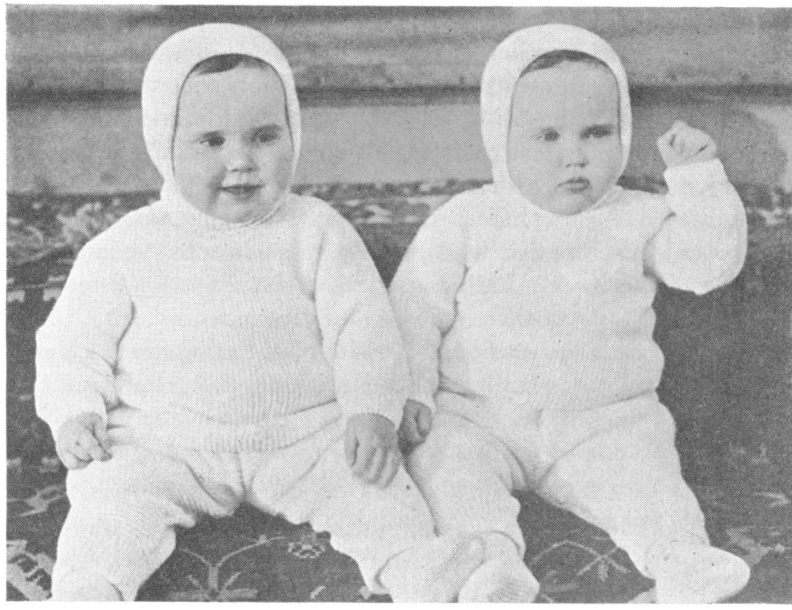


FIGURE 3. TWINS A AND B IN BABYHOOD

they very early showed unmistakable signs of more than ordinary alertness and attainment. At six months A startled her mother by rising suddenly into a sitting position in the mother's lap. Very soon after this B showed the same capacity. (Figure 3.) At 11 months they had both begun to walk and talk; indeed they were talking sentences, such as, "I see you, Auntie, * * *." They spoke clearly with less than the usual infantile lisping; and, according to report, with more than the usual degree of purposive, voluntary speech imitation. In October, 1915, at the age of three they began the study of French, and in less than a year (by April, 1916) they were reading elementary English, French and Esperanto. Their mother was a very constant companion; and stimulated this development by the aid of plays and games, but the children needed no prodding. They were distinguishing parts of speech with the aid of a Teddy Bear at the age of four; and at the same age one of them asked a searching question in regard to the Immaculate Conception. Formal arithmetic was begun at the age of six, and in less than a year they were solving mentally problems in fractions and percentage. They entered Grade III at the same age, and now at the age of nine, they are in Grade VII, doing Junior High School work. They are not prigs: they are attractive, animated, sociable children, with a bubbling sense of humor. They are popular with their playmates. They can take charge of a gymnasium class in which most of the members are two to four

years their seniors, and preserve excellent attention and discipline. They speak mature but not pedantic English, and they speak French with the fluency of a native. They have read Genesis in Italian and are now speaking a little Italian. They have read the Book of Knowledge in its entirety in French; and a year ago embarked on Russian. They play duets on the piano; but not with rare distinction. They swim; they ride horseback; they write jingles, and they read by the hour. Their school work does not tax them; they do not worry about it; and they are far from fastidious in regard to the form of their written work.

In this brief general review of their developmental history it is impossible to make any noteworthy distinctions between A and B. They have been inseparable, and abreast. Physically as well as mentally there has been a correspondence. They have both escaped most of the children's diseases; and neither has suffered a physical setback. So that now, as when they were babies, they are practically interchangeable children. The general impression made by physique, countenance, demeanor, conversation is one of complete similarity. A rather thoroughgoing analysis does not seriously disturb this impression of underlying identity of psychophysical make up.

(b). Physical Tests and Measurements

Some twenty-five physical tests and measurements were made to determine the degree of physical correspondence between A and B. The results of this portion of the study are summarized in the accompanying table. An inspection of this table will show that in many items the correspondence amounts to complete identity and that in others it amounts to practical identity. Nowhere was a pronounced deviation revealed. The difference in standing height is one fourth inch in favor of A. The sitting height shows the same difference. Corresponding to this there is a difference of only one pound in weight. This disparity, however, is a variable one and sometimes B is slightly ahead of A in weight. The head girth shows a difference of but one eighth of an inch and the cephalic index which represents the relation between width and length of head shows a difference of only 0.7. The cephalic width is only 0.2 mm. greater in the case of B and the cephalic length 0.1 greater in B.

A very interesting and tangible criterion of anatomical development consists in the degree of ossification of the carpal bones. It is possible to ascertain this degree of ossification by a precise measurement of the exposed bone area as revealed by the X-ray (Figure 4). Such measurement can be made by means of the planimeter.

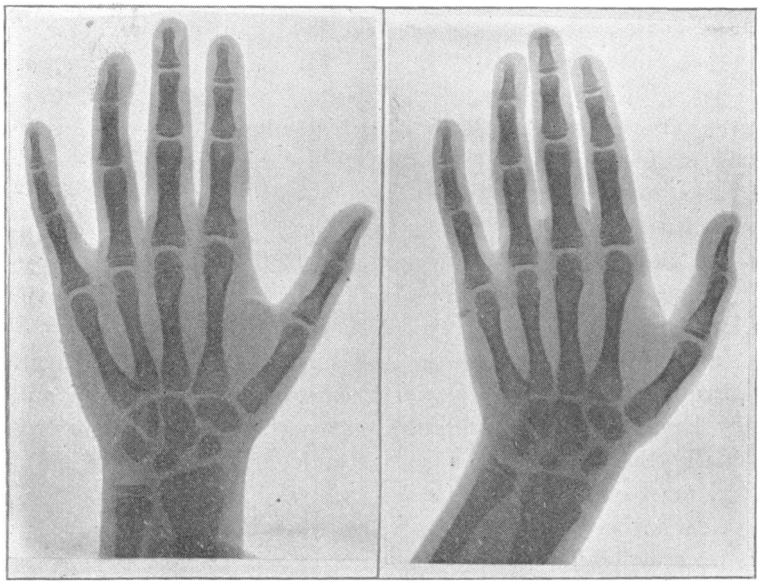


FIGURE 4. X-RAY PHOTOGRAPHS OF LEFT HANDS OF A AND B
Showing close correspondence in ossification of carpal bones.

Since, however, we were purely interested in making a comparison between A and B, our measurements were made by ascertaining the two major right angle diameters by means of a mm. rule. An examination of the table will show that four of the seven bones measured exactly alike. In the three other instances there was a

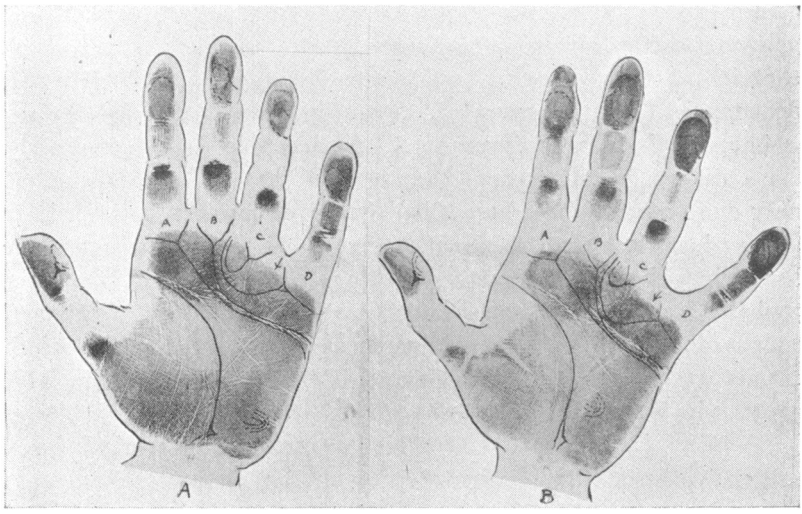


FIGURE 5. PALM PRINTS OF TWINS
Showing identity of skin patterns of right hands of A and B.
Formula, 9-9-5-5.C.

PHYSICAL TESTS AND MEASUREMENTS OF TWINS, A AND B, AGE 9

ITEMS COMPARED	A	B
Standing height	48⅞	49⅝
Sitting height	25¾	25½
Weight	56½	55½
Head girth	20½	20⅝
Head width (mm.)	13.4	13.6
Head length (mm.)	16.5	16.6
Cephalic index	81.2	81.9
Diameters of carpal bones:		
Scaphoid	5 x 10	5 x 10
Semilunar	7 x 10	8 x 11
Cuneiform	7 x 11	7 x 11
Trapezium	9 x 10	9 x 10
Trapezoid	7 x ca 7	7 x ca 7
Os magnum	11 x 20	12 x 20
Unciform	8 x 15	9 x 15
Total exposed area	676	724
Friction skin patterns:		
Right palm	9955C	9955C
Left palm	9955C	9955C
Right sole	do.	do.
Left sole	do.	do.
Blood pressure:		
Systolic	95	96
Diastolic	65	70
Pulse (resting)	104	110
Blood agglutination group	II	II
Vaccine pock	do.	do.
Dynamometer:		
Right hand	13	12
Left hand	12	11
Spirometer	78	80
Tapping rate:		
Right hand	130	130
Left hand	127	118
Steadiness	14	17
Dentition	do.	do.
Birth mole (upper lip)	do.	do.

disparity of only one mm. in one or two diameters. Calculating the area on the basis of these diameters it appears that the total carpal bone area of A is 676 square mm. and of B 724. This is a very slight difference indeed and is no greater than that which is often found between the right and left hands of the same individual. According to Baldwin's figures, an average disparity of about 50 square mm. is to be expected between the left and right carpus. Baldwin has made a comparison of the carpal development in four pairs of fraternal (non duplicate twins) and the average amount of difference in bone area of these four pairs is 421

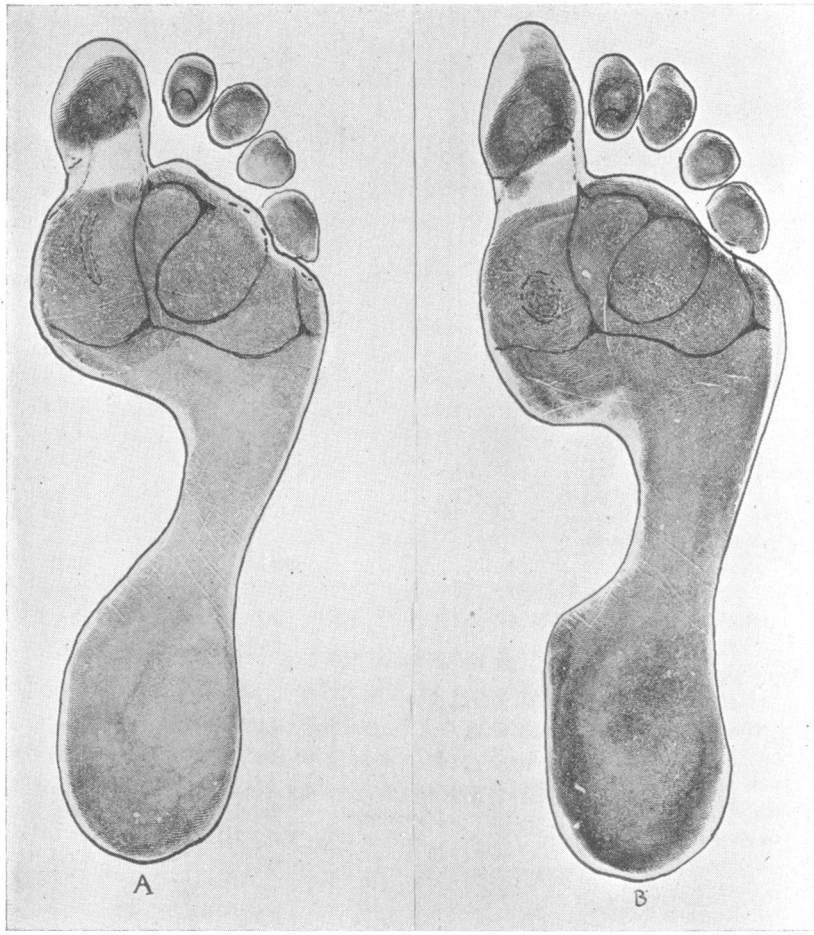


FIGURE 6. PLANTAR PRINTS OF TWINS
Showing identity of skin patterns of right feet of A and B.

sq. mm., a difference over ten times greater than that found in A and B, whom we regard as duplicate twins.

There is no more interesting means of making a physical comparison than that reported by the friction ridges of the skin. These friction ridges are found only on the surfaces of the palm and the sole. According to the comparative anatomist they date back to an arboreal ancestry, when certain animals in their active life among the boughs were much benefitted by the non-skid qualities of such ridges. The ridges were coarser in those days; but we still inherit them in indestructible patterns which appear in the fourth month of intra uterine life and are carried to the grave.

Sir Francis Galton said "Let no one despise the ridges on account of their smallness for they are in some respects the most

important of all anthropological data.'' Even in the ridge details there is absolutely no change in an individual from birth to old age. They furnish, therefore, a powerful aid not only for purposes of identification but for the comparison of individuals. A study of the palms and soles of A and B were made by Wilder's method. The right palms and right soles were mapped out to indicate the major subdivisions of the skin patterns. A remarkable degree of identity was shown in both the palmar and plantar patterns (Figures 5 and 6). The formula for the palm patterns is the same for both palms of both individuals, namely, 9.9.5.5.c. A minute analysis of certain areas of these patterns will show that the developmental correspondence has extended even to some of the minutiæ which are not regarded by Wilder as subject to detailed hereditary control. If the psychological correspondence of these two children approximates to any degree their anthropometric correspondence as indicated by the palm and sole diagrams, it is very great indeed.

A measurement of the blood pressure showed a difference of only one mm., systolic measurement and 5 mm. in the diastolic. Of these two measurements the systolic can be more accurately made and it is also the more important and the more readily ascertained. The correspondence is interesting. The resting pulse showed a difference of about six beats to the minute. A chemical diagnosis of the agglutination properties of the blood was made. In both cases the test showed the blood to belong to group II.

The development of bio-chemical tests for the measurement of individual differences is still in its infancy. The Benedict test for the determination of minute quantities of sugar in normal urine is supposed to reveal personal equations, but the conditions for accurate tests were too complex to carry out. An interesting similarity of a bio-chemical character was, however, exhibited in the reactions of the two girls to vaccination for smallpox. In both instances there was a very slight reaction without constitutional symptoms which occurred at the same time for both children. The dynamometer, spirometer, tapping and steadiness tests are included in the table because they have physical as well as psychophysical aspects. The differences revealed by these tests were very small indeed. The tapping rate for the right hands was identical.

Dentition is of course related to development. The first dentition could not be observed, but when the children were 8 years of age, the right upper permanent incisor was in both children in a similar incompleted stage of eruption. This is shown in the accompanying photograph (Figure 7) and presents a rather

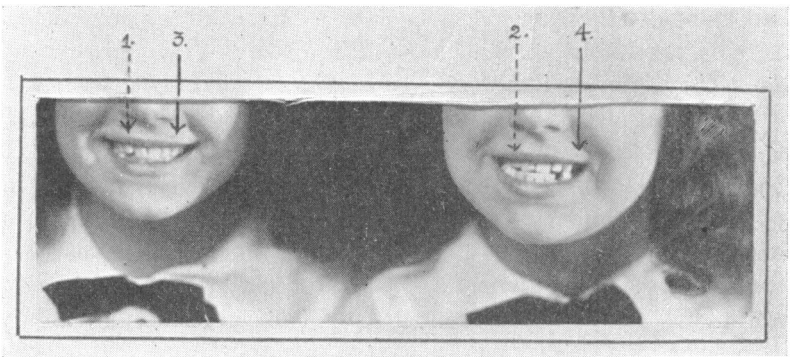


FIGURE 7. TWINS A AND B AT AGE 8
Showing correspondence in eruption of right upper incisor (1 and 2); and in location of tiny pigmented mole near left corner of mouth (3 and 4.)

startling indication of developmental correspondence. Finally may be mentioned one permanent indication of underlying identity of constitution. This is a tiny pigmented birth mole on the upper lip, situated a short distance from the left outer corner of the mouth in both twins. So here "the standard mole of the penny-novelists" could not even be relied upon for the purpose of personal identification, because both twins have the self-same mole! (Figure 7.)

There are several very tiny pigmented areas in the facial skin which are limited to one twin; and there are no doubt other physical deviations which minute study would disclose. Even two hairs, each but a half inch in length, taken from the same head, would as Wilder says, prove to be "absolutely unlike if magnified sufficiently to show the epidermic markings that cover the surface with a fine tracery." By such ultra refined standards, complete identity is a mathematical impossibility; but general, coherent correspondence and absolute identity are two quite different considerations. Our data compel us to recognize a basic developmental and physical correspondence in Twins A and B.

Since this correspondence has expressed itself in such structural details as teeth, skin patterns, birth moles, and cranial and carpal bones, it is not unreasonable to suppose that it should also assert itself in the general architecture and organization of the nervous system. We can gather some light on this point by inquiring into the mental correspondences, through the use of psychometric methods.

(c) Mental and Educational Measurements

The adjoined table summarizes the results of a group of intelligence, performance, and educational measurements of A and B

which were made at the Yale Psycho-Clinic, and at the home of the children. The writer wishes to acknowledge the assistance of Dr. Margaret Cobb in the administration of these tests. The co-operativeness of the subjects who entered into all of the situations in the spirit of a game, enlivened with rivalry, aided us. The subjects deserve our especial thanks; for they were indispensable in this particular study.

Mental and Educational Test	A Score*	B Score*	A Age Norm.	B Age Norm.	Remarks
1. Binet, Age 7	188	181	13.5	13	Average I. Q.: A, 183+ B, 183
2. Binet, Age 8	179	185	14.75	15.25	
3. Vocabulary, Age 7	50	50	14	14	
4. Vocabulary, Age 8	52	54	14+	14+	
5. Vocabulary, Age 9	67	65	16	16	
6. National Intelligence, Age 9	136	155	15	15+	
7. Porteus			12.25	11.25	A shows more foresight.
8. Ship	18	20	11	13	
9. Feature Profile	150 s	250 s	15	10	
10. Diagonal	195 s	70 s	6	10	
11. Triangle	25 s	30 s	14+	14	
12. Knox Cube	7	10	14—	18	
13. Healy A	205 s	135 s	9	10	
14. Seguin Form Board	28 s	30 s	7+	7	
15. Healy Coordination	305	445			A more deliberate.
16. Opposites	40 s	80 s			B spent 45 sec. on last word.
17. Easy Directions	98 s	85 s			No errors; both showed intense interest and attention.
18. Hard Directions	175 s	155 s			
19. Symbol Digit	23.4	12.2	12	9	
20. Trabue Language Completion	13	13	13.5	13.5	
21. Kansas Silent Reading	12.9	21.5	12.5	13.5	
22. Woody Fundamentals of Arithmetic	28	26	12.5	12.5	
23. Ayres Spelling	VIII	VIII	14.5	13.5	
24. Ayres Handwriting	60	60	13	13	Differentiation increasing.
25. Drawing (Thorndike)	10.5	10.5			
Accuracy (15)	90%	80%			
Average for combined tests			13.6	13.9	
Average for performance tests			11.75	12	
Standard deviation	2.83	2.91			

*S = second.

The mental examinations were not, of course, all made at one sitting; but the twins were always submitted to the selfsame tests on the same days.

The results of these tests for which we have standardized age norms are plotted on the accompanying chart (Figure 8), in which the solid line stands for A's performance and the broken line for B's. It is hardly necessary to give mathematical expression to these curves. The two lines show a striking degree of cohesion. Note, for example, how they both plunge down on the formboard test, and how equally they rise on the vocabulary tests. The most pronounced disagreement is that shown in the feature profile test. Here there was apparently a more or less fortuitous circumstance, which disturbed B's attack of the problem. Indeed it is quite likely that not a few of the minor disparities shown in the performance scores in various tests indicate variation in the conditions of the test, beyond our control, rather than fundamental differences in mentality. In view of this, the amount of psychological correspondence actually revealed by the tests is all the more significant.

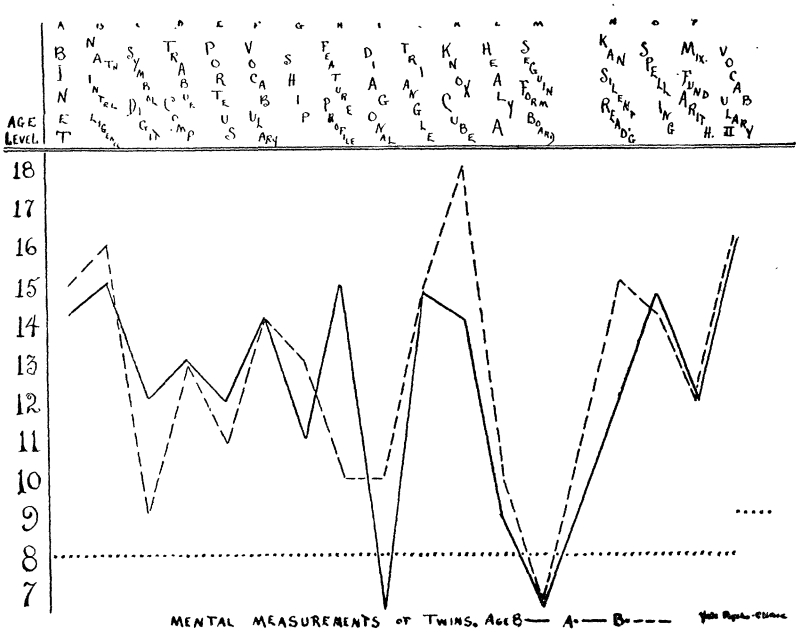


FIGURE 8. GRAPH SHOWING CORRESPONDENCE IN MENTAL MEASUREMENTS OF A AND B

The results are plotted on the basis of mental age scores, the heavy straight dotted line representing the chronological age. The tests in order are (*a*) *Binet*, (*b*) National Intelligence, (*c*) Symbol Digit, (*d*) Trabue Completion, (*e*) *Porteus*, (*f*) *Vocabulary*, (*g*) *Ship*, (*h*) *Feature Profile*, (*i*) Diagonal, (*j*) Triangle, (*k*) Knox Cube, (*l*) Healy A, (*m*) Seguin Form-board (*n*) Kansas Silent Reading, (*o*) Ayres Spelling, (*p*) Woody Mixed Fundamentals of Arithmetic, (*q*) Vocabulary II.

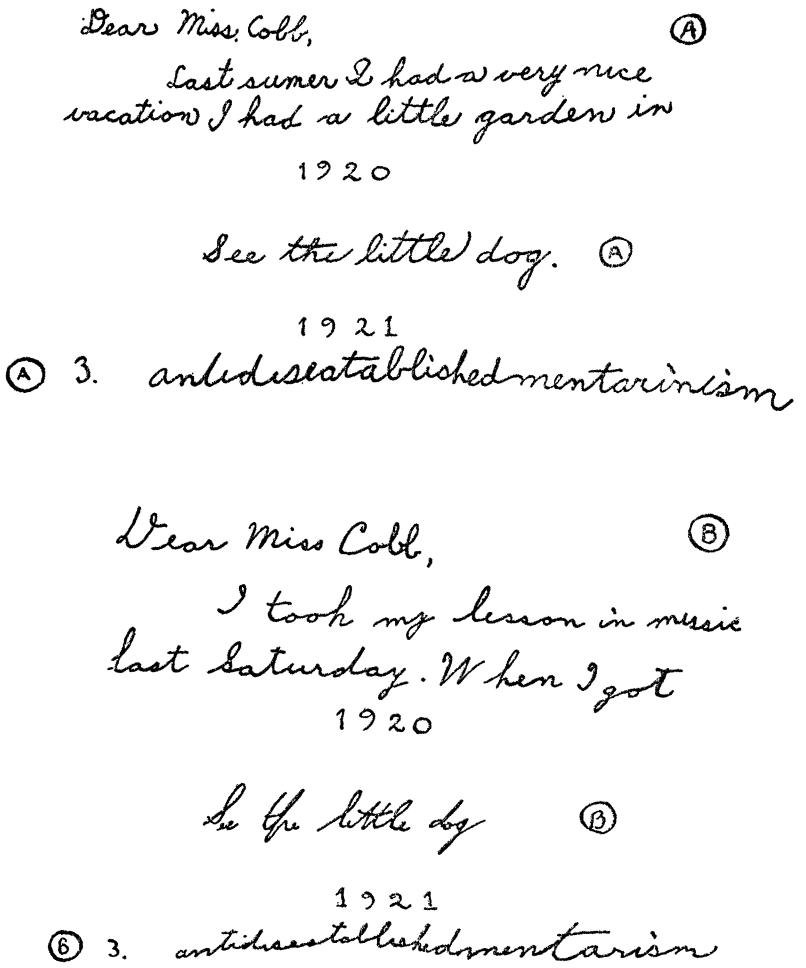
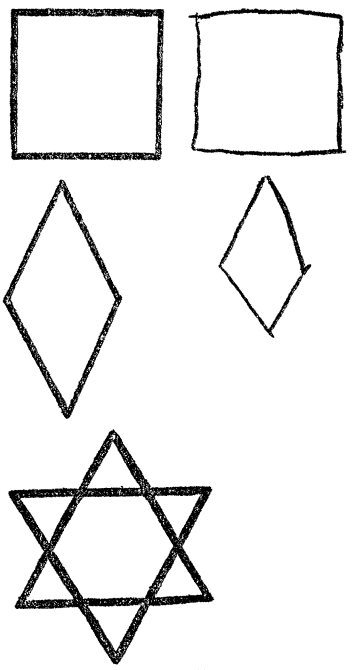


FIGURE 9. HANDWRITING OF A AND B (REDUCED TO TWO-THIRDS)
Showing a moderate degree of similarity in 1920 specimens, and an accentuation of points of difference a year later. The specimens marked 3 show the third trial at spelling the "word," *antidisestablishmentarianism.*

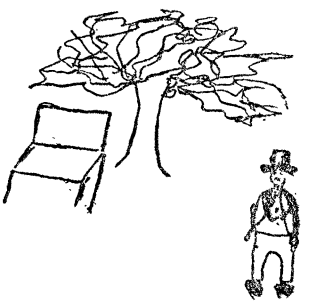
Qualitatively as well as quantitatively the tests revealed a consistent similarity with respect to general alertness, intensity of attention, deliberation, cooperativeness, sense of humor, and emotional reactions. Comparative ratings with regard to quality of responses were attempted in 25 of the Binet tests. In 12 of these our rating was equality, in 13 a slight superiority in favor of B who showed perhaps a little more directness, conciseness and power of generalization. But these ratings were subjective at best, and rested so near to the limit of imperceptible difference, that it would be pedantic to insist on their importance. For once let us insist on resemblance rather than differentiation.

18. Give the child a pencil (but no ruler) and say: You see that (pointing to the square). I want you to make one just like it. Make it right here (pointing to the space adjoining). Go ahead. Repeat this formula for each figure.



19. Point to the round field, and say to the child: *Let us suppose that your ball has been lost in this round field. You have no idea what part of the field it is in; but you know it is there somewhere. Now take this pencil and begin at the gate and mark out a path to show me how you would hunt for the ball so as to be sure not to miss it.*

In the space below have the child draw a man and a tree with a bench under it. Give no further directions or assistance.



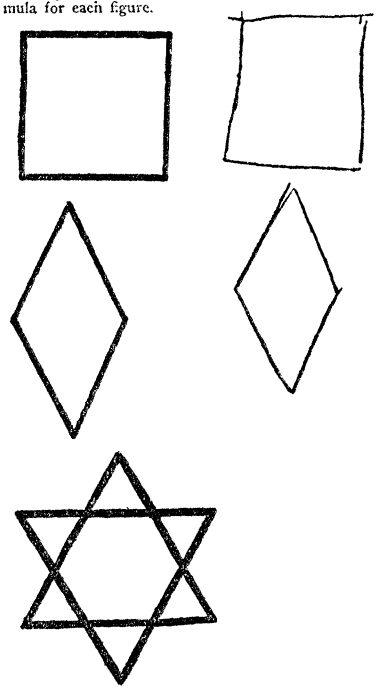
Draw Star Here

FIGURE 10. DRAWING TESTS—TWIN A

In addition to the purely psychological tests, several educational tests were given to measure achievement in reading, writing, arithmetic, spelling and drawing. The results showed close similarity in every instance, with the exception of silent reading, in which B made a somewhat superior score.

In spelling, the standard Ayres word list was used. By way of good measure, the girls were also given a chance to spell "the largest word in the language." They responded with their usual eagerness. I pronounced, three times, the formidable "word" *antidisestablishmentarianism.* They tried to spell it after each

18. Give the child a pencil (but no ruler) and say: You see that (pointing to the square). I want you to make one just like it. Make it right here (pointing to the space adjoining). Go ahead. Repeat this formula for each figure.



In the space below have the child draw a man and a tree with a bench under it. Give no further directions or assistance.

Draw Star Here

19. Point to the round field, and say to the child: *Let us suppose that your ball has been lost in this round field. You have no idea what part of the field it is in, but you know it is there somewhere. Now take this pencil and begin at the gate and mark out a path to show me how you would hunt for the ball so as to be sure not to miss it.*

FIGURE 11. DRAWING TESTS—TWIN B

pronunciation. The results of the third trial are shown in the illustration. Both inserted a superfluous *ed,* in the middle; A missed the rest of the word by one letter, and B by three. (Figure 9.)

The reactions of the twins in the field of drawing are pictured in the accompanying illustrations, (Figures 10 and 11). The twins were asked independently to copy a square, a diamond and a star; to trace the route in the ball and field test, and to draw (without copy) a man and a tree with a bench under it. These responses under controlled conditions furnish a basis for objective comparison. The general similarity is unmistakable, as

shown by the illustrations. The similarity of the free drawings of man, tree and bench is the most remarkable. It can, of course, be partly accounted for by the conventionalizing effect of reciprocal imitativeness, favored by the intimate companionship of these two children; but after all the fact that this conventionalizing process should produce such an assimilative result denotes an underlying similarity in mental constitution.

Handwriting is an expression of individuality. It is not necessary to go as far as the graphologists do and consider it an index of character; because it is of course subject to fortuitous, mechanical and purely technical influences. However, Wilder and Wentworth are probably correct in their statement that "more than any other single gesture or habitual pose, a man's natural handwriting is the product of what he has experienced, learned, and practiced repeatedly, mind and body cooperating in every stroke." Osborn interprets penmanship as the combined product of muscular habits and mental patterns which "differ in a marked manner in different individuals and this variation radically affects the visible result." On these constitutional variations rests the possibility of identifying individuals and detecting forgery through handwriting.

When it comes to a comparative study of twins, handwriting therefore suggests itself as a psycho-motor test. It must indeed be a delicate test, for complete similarity is apparently very rare. Galton, however, reports one case in which not even the twins themselves, though adults, could distinguish their own handwriting. In our own case of A and B, there was a moderate degree of similarity at the age of 8, as shown by the accompanying illustrations (Figure 9). The reader will note, however, a little more angularity, compression and reduction in size, in B's specimen. These differences in the course of a year have become accentuated, so that the general similarity of the earlier stage is disappearing. That the differentiation will grow still more marked with adolescence is not improbable. And who knows what other chirographic metamorphoses will attend this period, in which individualism in loops, hooks, flourishes, etc., frequently abound?

The vocabularies of A and B deserve particular discussion; because we may feel certain that these two girls have been subjected to a nearly identical language environment. They have been inseparable; they have talked and held their tongues to very nearly the same extent; they have had the same mother, the same mother tongue; they have had equal instruction in the same foreign languages; they have listened, usually at the same time to the

same relatives, friends and teachers; have studied the same lessons and have read much the same books. With what results?

It would be fallacious to say, that *because* A and B have been exposed to the same verbal environment, they will be familiar with the same words. Familiarity with words depends upon other factors than mere impression. It depends upon the capacity to assimilate meanings, concepts, contexts, inflections. It depends upon curiosity and attitudes, upon social propensities, tastes, preferences, and above all upon maturity.

Numerous psycho-metric determinations of the vocabulary of children have shown a consistent tendency for the vocabulary score to increase with age, and with intelligence. Vocabulary is so highly correlated with mental development, that even the son of an immigrant, who hears nothing but a foreign language at home, will after brief residence in this country earn a high vocabulary rating, if he is of superior endowment.

Our twins have since babyhood shown a sprightly facility in the realm of words. They have taken much delight in various forms of sound and word play, and have betrayed a lively and often humorous interest in words. Both of the children like to rhyme, and B is blossoming into poetical composition. The accompanying sample is not unpromising, when we consider that the chronological age of the "poetess" is nine!

THE BIRTH OF FLOWERS

When flowers first were born,
The earliest flow'r of Morn,
Was the Rose,
So Sweet and wondrous in its
pose.
The flowers all assembled
To chose their Queen,
The fairest one amongst
them I ween;
The rose spoke up
And said, "The one that
goes latest to
bed."

It was possible to make a satisfactory comparison of the twins A and B by means of a vocabulary test. This test, Terman considers to have a far higher value than any other single test in the whole intelligence measuring scale. The test consists of 100 words derived by random selection from a dictionary containing 18,000 words. An abbreviated series of 50 words of increasing difficulty ranging from *gown* and *tap* to *shagreen* and *complot* was given to both A and B. This virtually constituted a graded scale of 50

individual tests, and revealed a startling degree of resemblance; A failed on 16 of the test words; B failed on exactly the same words, and on only one additional word, namely *harpy*. The calculated vocabulary score of A at the age of 9 is 65 and for B it is 67, a standard equivalent to the average adult level.

VOCABULARY TEST

	A.	B.		A.	B.
1. gown	+	+	26. Mars	+	+
2. tap	+	+	27. mosaic	+	+
3. scorch	+	+	28. bewail	+	+
4. puddle	+	+	29. priceless	+	+
5. envelope	+	+	30. disproportionate	+	+
6. rule	+	+	31. tolerate	+	+
7. health	+	+	32. artless	—	—
8. eye-lash	+	+	33. depredation	—	—
9. copper	+	+	34. lotus	+	+
10. curse	+	+	35. frustrate	—	—
11. pork	+	+	36. harpy	+	—
12. outward	+	+	37. flaunt	—	—
13. southern	+	+	38. ochre	—	—
14. lecture	+	+	39. milksop	—	—
15. dungeon	+	+	40. incrustation	—	—
16. skill	+	+	41. retroactive	—	—
17. ramble	+	+	42. ambergris	—	—
18. civil	+	+	43. achromatic	—	—
19. insure	+	+	44. perfunctory	—	—
20. nerve	+	+	45. casuistry	—	—
21. juggler	+	+	46. piscatorial	—	—
22. regard	+	+	47. sudorific	—	—
23. stave	+	+	48. parterre	—	—
24. brunette	+	+	49. shagreen	—	—
25. hysterics	+	+	50. complot	±	±

+, passed. —, failed.

This degree of correspondence is truly remarkable when we reflect that this searching test, in a statistical sense, compasses the whole wide domain of the English language. Although we must give due weight to the similarity of verbal and academic environment to which A and B have been subjected, do not the results of the test testify even more eloquently to an underlying similarity of nervous constitution and organization?

Incidentally we may record a characteristic reaction which occurred in the course of the first vocabulary test which I gave to the twins at the age of 7. A encountered a word which sounded familiar, but for which she could frame no definition. The word was *civil*,—"Civil, don't know; can't say; and yet I think I know. O, that reminds me: it is like that story about space. A teacher asked his pupil to define *space*. The boy said, 'I can't tell you what it is, but I've got it in my head.'" Thereafter, whenever

an unfamiliar word was presented, A smiled slyly, tapped her head and said, "I guess it's that space story again!" Even so, both girls at the age of seven had a vocabulary score of 50, equivalent to the mental age of 14. Moreover, they knew when they didn't know. Mentally inferior children venture wild definitions in the field of the unknown.

There are no satisfactory objective methods for directly measuring emotional and volitional traits. We, of course, secure data concerning them indirectly through so-called intelligence measurements; but we are chiefly dependent upon clinical inference and estimate. Even so, it would require a psychological Boswell to furnish a complete comparative picture of the temperaments and dispositions of A and B. Long continued and intimate observation might reveal some interesting disparities in the emotional sphere. The ordinary observer would probably develop a partiality for one of the twins on the ground that A or B is less assertive, more reasonable, more affectionate, than B or A. But this preference might indicate the inveterate selective and discriminative tendency of human perception, quite as much as a fundamental diversity in the twins.

Assuming that there is at present a high degree of correspondence in temperamental traits: does it follow that such will always be the case? Hardly so. To begin with these children have not as yet come into full possession of all of their mental inheritance. Adolescence brings with it many new psychic characters, and these may not be equally shared, or equally assimilated by A and B. And as we look down the future we must reckon with the differentiating power of differences in fortune, social position or professional career. We have noticed that one twin is definitely more dependent upon demonstration of affection by the mother; that one is becoming interested in the violin, the other, perhaps in poetry. Suppose that one should seek distinction in music and the other in letters. Even such a relatively small disparity in vocation might ultimately create by accretion a very decided difference in mental content, habits of thought, social attitudes, outlook upon life; so that the conditioned reflexes and complexes of A would become quite distinguishable from those of B; an interesting difference in vegetation, growing upon much the same soil. Personality in its higher expressions is always so conditioned by social and educational factors that it would be futile to deny the possibilities of differentiation even with "duplicate twins."

But we are concerned with the present status of twins A and B, age 8. At that age we gave them an opportunity to express some of their likes and dislikes on paper. It was a simple, almost

impromptu test; but the results were amazing. They independently answered in writing a questionnaire, which is reproduced with their replies exactly as they gave them.

QUESTIONS ON LIKES AND DISLIKES, ANSWERED IN WRITING INDEPENDENTLY BY A AND B

Question: If you had $1,000.00 to spend, how would you do it? Tell me about it on this page.

Answer: A. I would buy a painting outfit and learn to use it. Take Mother to Europe (because she wants so much to go).

B. I would buy a horse (like Black Beauty), a riding habit, the Universal Anthology for Mother and a barrel of sugar for my horse.

Question: What is the most unpleasant thing you have to do every day?

Answer: A. Practice on the piano.

B. Practise on the piano.

Question: What is the most agreeable thing you do every day?

Answer: A. Ride horse-back.

B. Ride horse-back.

Question: What is most likely to make you angry?

Answer: A. Our dog.

B. Rasputin. (The dog.)

Question: What is it your ambition to be when grown up?

Answer: A. An artist.

B. To teach.

Question: What game do you like best?

Answer: A. Play lady and dress up in Mother's clothes.

B. Mother.

Question: What was the most fun you had last summer?

Answer: A. Going in swimming.

B. Going in swimming.

Question: What is your favorite color?

Answer: A. Green.

B. Green.

Question: What is your favorite book?

Answer: A. Bible stories.

B. The Bible.

Question: What is your favorite song?

Answer: A. Red, White and Blue.

B. Home Sweet Home.

Question: What is your favorite study in school?

Answer: A. Reading.

B. Reading.

It would be easy to exaggerate the significance of these questionnaire results, and yet it is inconceivable that they would have been possible without a considerable degree of correspondence in personality traits. The same conclusion must be drawn from the results of the vocabulary tests made at seven, eight, and nine years of age. The close correspondence in mental level revealed by the Binet ratings is also undeniable. There were several points of difference in the I Q at the ages of seven and eight, but the average for the two testings was within one point,—183.

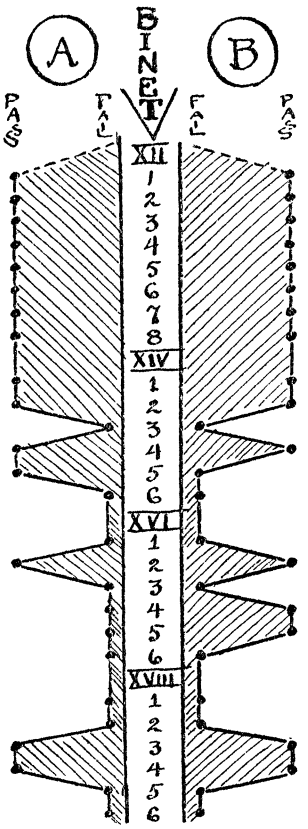


FIGURE 12. COMPARATIVE PSYCHOGRAPH

Showing intellectual correspondence of Twins A and B at age 8. Forty-four graded intelligence tests were given. All the tests at the mental age levels of 8 to 12 inclusive were passed with facility.

The I Q, or Intelligence Quotient, expresses the ratio of mental age to chronological age. If these two ages are the same in a given individual the I Q is 100. If the mental age is less than the chronological, the I Q is below 100. If the mental age is in advance the resulting I Q is above 100. Children with an I Q of 65 or less are usually feebleminded. Children with an I Q of 120 or more may be regarded as relatively superior. The psychological literature reports very few cases with an I Q as high as 180.

A comparative psychograph of the performances of A and B in the Binet tests gives a fair graphic picture of the degree of intellectual correspondence of these two children at the age of 8. The diagram (Figure 12) is so drawn that success and failure are indicated in corresponding meridians. All the tests in the age levels below 12, were passed with great facility and are not included.

One half of the psychograph proves to be almost a mirror image of the other.

(d) General Conclusion

Reviewing, then, the developmental history of A and B, and the results of scores of tests,—the physical, the anthropometric, the psychological, performance and educational measurements; and considering the collective weight and tendency of these findings, and the wider diversity which would have been shown by a similar study of ordinary siblings—it seems highly probable that this pair of twins were of nearly duplicated or identical genetic antecedents.

The general conclusion is inescapable that the consistent similarity between these two children is based upon a fundamental, inherent similarity in endowment. It would, however, be wrong to ignore the equalizing influence of a practically identical environment. Indeed, in studying the development of personality it is rather artificial to bring nature and nurture into rigid contradistinction. Personality represents the resultant cooperative product of both intrinsic and extraneous factors, and the interaction of these factors in highly dynamic relations. It is because these dynamic relations are so sensitive, that any marked psychological similarity even between co-twins at the relatively old age of eight years is impressive. It may even be usual that one of a pair of twins begins with or early acquires a physical or temperamental advantage which gives him a different status in the social situations of life; and initiates a differentiating process which waxes with what it feeds upon. But in the present instance, such a strong differentiating tendency has not become very apparent. I should not be willing to say that it will never come into power. We have already suggested the differentiating possibilities of a wide difference in vocational or social careers. Even now a consistent partiality for one child on the part of the mother, a physical accident or an unshared illness, or an emotional crisis limited to one child, might become the germ for a pronounced differentiation of personalities. But on the whole, the equalizing factors have hitherto with A and B remained dominant.

Among these factors we should mention a pleasant degree of jealousy and emulation. Neither wishes to be out done by the other. For example, when at the age of seven I gave them the delightful privilege of filling my hod with chunks of cannel coal, they both insisted that they be permitted to put on the big gloves and that they also be permitted to put exactly the same number of chunks into the hod. This propensity, which fundamentally is

hereditary, has preserved a kind of balance of power and has helped to impress a certain identity on their respective personalities. Neither has become a leader of the other.

The argument that similar experiences have made these children similar does not bear close scrutiny; experience, after all, is a descriptive term for the reactions of an organism to its environment. As Dewey puts it, the combination of what things do to us in modifying our actions, and what we can do to them in producing new changes constitutes experience. From a clinical point of view, the experience argument begs the question. What we really wish to know is to what degree have these children actually had similar experiences. Our conclusion is that they have manifested similarity of experience to a remarkable degree, due primarily to the structural parity of the nervous system with which they were endowed. A similarity of environment has developed a corresponding functional parity. But here again the considerations become involved; for this so-called similarity of environment has consisted not only in the same house, similar beds, similar clothes, similar food and identical instruction; but the twins have had each other, and each has carried around much the same environment, because each apparently assimilated much the same things for her milieu. There has at least been a high degree of reciprocity between nature and nurture!

(*To be concluded.*)